2000 CALFED Science Conference
Session Notes

Organic Carbon and Lower Trophic Level Processes

Session Chair: Wim Kimmerer for James T. Hollibaugh
Session Notetaker: William V. Sobczak

Basic Science in Support of Ecosystem Restoration: Lessons from a Research Program Supported by CALFED Category III - James Cloern, USGS

Cloern argues that many complex environmental problems require orchestrated teams with researchers with a diversity of backgrounds and interests. He contends that, when successful, the whole (the research TEAM) can exceed the sum of the individual parts (contribution of INDIVIDUALS). Cloern stresses the need for broad and creative thinking when addressing delta research problems. He argues that a combination of historical analysis, hydrodynamic modeling, field experiments, and laboratory experiments yield collective insight into the delta that would NOT have been gained with isolated contributions. He provides an example of INTEGRATED Science that includes a diversity of collaborators. What may appear to be a simple, fundamental question: "What sources of organic matter fuel biological production at the base of the food web in the delta?"…………….requires the contribution of an integrated TEAM to properly and thoroughly answer.

Food Quality and Quantity for Daphnia in the Sacramento-San Joaquin Delta Estuary - Anke Mueller-Solger, UC Davis.

Are there habitat-specific differences in Daphnia (a "model" zooplankton) growth potential in the delta? If so, does variation in the amount and quality of POC contribute to these differences? This fundamental question is very difficult to answer in a rigorous scientific manner due to variations in environmental conditions (e.g. temperature, turbidity) and species'-specific characteristics (e.g. mean size, seasonal-variation in egg production). The authors remedy these problems by devising a creative and carefully controlled laboratory bioassay in which the growth of clones of Daphnia can be monitored following experimental additions of POC from various delta habitats. The authors report a large amount of spatial and temporal variability in growth responses. More importantly, the authors discovered that a large portion of this variation could be explained by variation in the amount of POC. More specifically, variation in the amount of algal biomass, an important component of POC, proves to explain a surprisingly large percentage of the variation. The authors used a smart statistical analysis to separate the role of POC and algal biomass (they are NOT independent measures). Future work will investigate the mechanisms that underlie the relationship between Daphnia growth and algal biomass.

Organic Matter Sources for the Delta's Food Web - Alan Jassby, UC Davis

The authors summarize the findings from a retrospective-historical analysis of a 30-year IEP data set. The authors use a combination of standard and novel statistical approaches to analyze multiple time-series of data. The authors constructed a DELTA-WIDE organic carbon budget based on this 30-year data record. The authors argue that river-derived organic matter and within-delta phytoplankton production constitute that two main organic carbon sources to the delta. Surprisingly, agricultural inputs and marsh inputs did NOT contribute to a large portion of the organic matter load. In addition, the authors examined 30-year trends in within-delta algal production at an array of IEP sampling stations that cover the delta. Overall, phytoplankton biomass has been declining in the delta. This work is in press and should be examined and cited by individuals who would like to reference these findings. Please see: Jassby, A. D. and J. E. Cloern. 2000. Organic Matter Sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation, In Press.

Impact of Temporary Barriers and Flow through the Yolo Bypass on the Transport of Organic Carbon through the Delta - Nancy Monsen, Stanford University

The authors have carefully constructed a multidimensional numerical model to help explain delta transport of "anything that moves with the water". The authors highlight several important uses of this modeling approach. The authors pursue clear and carefully constructed questions because the computational demands are intense and computer runs are slow. Most delta researchers conceptualize the delta as two rivers flowing into an immediately-mixed confluence, but in reality the mixing of the two rivers is extremely complex. The authors demonstrate how the model can resolve the relative contribution of river-water sources at various delta locations. The utility of such an approach seems endless. For example, what is the influence of fish-barrier X, or levee-breach Y, or pumping strategy Z on the mixing of Sacramento and San Joaquin River water? Bottom line: Delta chemistry and biology is resolved with knowledge of delta hydrology.

Spatial Variability in Ecological Function Between and Within Flooded Islands: Lessons for Restoration and Monitoring - Lisa Lucas, USGS.

The authors describe a thorough, carefully designed series of experiments that aimed to understand the production and fate of algae in two adjacent shallow water habitats (Franks Tract and Mildred Island) in the delta. Algal biomass and critical environmental factors that regulate algal production were measured in a careful and calculated manner so that spatial variability within the shallow water habitats could be analyzed and then compared among tidal conditions and between habitats. This systematic sampling regime may be a model for other research groups to follow. More importantly, this research examines the fate of this variability in algal biomass by partitioning hydrologic losses (i.e. exchange with adjacent delta habitats) and biological losses (i.e. benthic grazing rates). This research provides remarkably clear practical lessons that will aid restoration decisions and actions: 1) monitoring must consider within habitat spatial and temporal variations, 2) the hydrology of the shallow water habitat (e.g. exchange with adjacent channels, residence time, depth) influences the biology, 3) algal production can be readily filtered by benthic grazers, hence some shallow water habitats may act as NET CARBON SINKS and serve to fuel secondary production in the benthic food web (as opposed to planktonic food web). The creation of shallow water habitats will most likely be a major focus of delta restoration action over the next 30 years, yet it is becoming increasingly clear that shallow water habitats, even if adjacent to each other, can have very different biological functions.

Organic Matter Sources in the Sacramento-San Joaquin River Delta as Inferred Through the Use of Biomarkers - Elizabeth Canuel, Virginia Institute of Marine Science.

Where does delta organic matter come from? Jassby and Cloern (see above) provided a “historical-analysis” approach to address this fundamental question? Canuel et al. ask this same question with a “chemical-signature” approach. Canuel is at the forefront of this rapidly-emerging, powerful IN SITU approach that examines the contribution of sterol and fatty acids that are associated with specific organic matter sources. In addition, the authors examine natural IN SITU variation in carbon and nitrogen isotopes to infer source. Samples were carefully analyzed for a variety of sites that represent different hydrologic inputs or within delta sources: Rio Vista on the Sacramento River, Mossdale on the San Joaquin River, a shallow-water habitat (Mildred Island), and an undisturbed tule marsh (Cutoff Slough). In general, biomarkers support the primary influences of phytoplankton and vascular plants on the POM composition. At Cutoff Slough, the authors observed increased phytoplankton sterol concentrations during October 1998 and 1999, but the concentrations of polyunsaturated fatty acids (PUFAs), which are indicative of organic matter lability, were similar throughout the year. Sterol concentrations from Mildred Island indicated that through most of the year, the dominant sources were plants, diatoms and crustaceans. Samples collected from October 1999 in the Southeast Cove of Mildred Island, compared to other Mildred Island sub-sites during the same cruise, indicated that the majority of organic matter produced there was from phytoplankton sources, indicating intra-site variability in this shallow-water habitat. Fatty acids reflected this pattern as well, with PUFAs being dramatically higher at MI-SE. Rio Vista samples demonstrated very little variability in either sources or lability throughout the year. Mossdale samples showed increased organic matter lability in January and July 1999. Ratios of unsaturated/saturated fatty acids, another measure of lability, also indicated that Mossdale consistently produced the most labile organic matter year-round of the sites studied thus far. Canuel et al. presented only a component of their delta-wide data set to illustrate the utility of this IN SITU organic matter “finger printing” approach.

Organic Matter Bioavailability among Habitats and Hydrologic Inputs in the Sacramento and San Joaquin River Delta - William Sobczak, USGS.

The authors partitioned organic matter into two ecologically significant size classes (dissolved and particulate organic matter) and two ecologically significant pools of quality (bioavailable to bacteria and refractory to bacteria). The authors summarized their findings with six FUNDAMENTAL PRINCIPLES: 1) In general, a small fraction of the total pool of organic matter is bioavailable. The author's assays for assessing potential bioavailability of DOC and POC maximize these estimates, yet they still found relatively small pools of potentially available organic matter. Hence, changes in the bioavailability of organic matter, not just the amount of organic matter, must be documented before and after restoration action. 2) The amount of dissolved organic carbon (DOC) is usually several times greater than particulate organic carbon (POC). DOC and POC enter food webs at different trophic levels, thus understanding the relative contribution of each is important in predicting organic matter transfer to higher trophic levels. 3) High concentrations of chla appear to be good predictors of bioavailable POC. Thus POC that contains a large fraction of algal biomass will likely be more bioavailable than POC without algal biomass. Habitats that support modest algal blooms are generally thought to be directly beneficial to planktonic filter feeders (i.e. they eat the live algal cells), however there may be additional indirect linkages to planktonic filter feeders if lysed cells or cell exudates can be incorporated into planktonic bacterial biomass. In addition, high rates of bacterial respiration and productivity are frequently coupled to high amounts of algal biomass. Microbial loop linkages to higher trophic levels probably increase during bloom conditions. 4) Tule marsh sites (i.e. Cut-off Slough) more closely represents the delta that existed before 1850. This site routinely generates our highest DOC and POC values, and can generate high chla values. In addition, the highest microbial responses are frequently generated at this site. Although shallow habitats may generate pulses of available OM, tule marsh sites probably provide larger and more continuous OM inputs. 5) In general, water from the Sacramento appears to deliver less available OM than water from the San Joaquin (when normalized to volume). This availability appears to be associated with higher algal biomass. The source of the water may affect the potential for primary production among flooded habitats. 6) In general, water draining from the Yolo-Bypass appears to have higher availability, especially during a falling hydrograph due to increased algal biomass generation. Floodplains may provide pulses of bioavailable OM that would not be generated during channelized flow.

Microbial Decomposition of Delta Organic Matter – Role of Photo-oxidation - Ramunas Stepamnauskas, University of Georgia.

The authors presented findings that are part of a large integrated project that examines the amounts, bioavailability, and chemical composition of DOC AND microbial and chemical transformations that can influence drinking water quality. The authors' findings complement those of Sobczak et al. in many ways (e.g. only a small fraction of the total DOC pool is bioavailable), even though the two groups employed slightly different methods and bioassays. Photo-oxidation, or chemical reconfiguration of organic matter after being exposed to sunlight, can result in chemically and microbially-mediated mineralization of organic matter (i.e. makes it become carbon dioxide), but the magnitude of such responses is highly variable. Surprisingly, the authors found that experimental exposure to "synthetic" light did NOT result in significant degradation of organic matter (relative to unexposed controls). In my opinion, this is an important finding because it suggests that the organic matter within the delta is so highly degraded (i.e. refractory) that induced photo-oxidation does not yield labile organic matter. The authors acknowledged that their findings are preliminary and based on only a few sampling dates.

A Comparison of Phytoplankton Bloom Dynamics in Suisun, San Pablo, and Central San Francisco Bays - Francis Wilkerson, SFSU Romberg Tiburon Center.

The authors lay out a prospectus for a new long-term ecological monitoring program in the central and northern SF-Bay Estuary. The discipline of Ecology and the Environmental Sciences, in general, have benefited from National Science Foundation Sponsored Long Term Ecosystem Studies. At first glance, this Environmental Protection Agency funded project seems to have valuable parallels to the NSF program. Such programs are critical for evaluating environmental change that occurs following unexpected biological invasions, or changes in nutrient regimes, or changes in hydrologic regimes, or changes in X, Y, or Z following delta or estuary restoration decision. The authors illustrate the value of such a program by documenting expected phytoplankton blooms (e.g. spring blooms in central bay) vs. an UNEXPECTED phytoplankton bloom in Suisun Bay.

Environmental Conditions and Lower Food Web Production in Northern San Francisco Estuary, 1975-1993 - Peggy Lehman, DWR.

Ecological long-term data sets are extremely valuable for a variety of reasons: they are rare (which makes them inherently valuable), they highlight OR expose rogue years or dates etc., they provide statistical POWER, they allow organisms with long or complex life-cycles to be studied, they generate hypotheses that would remain UN-generated with an amalgamation of shorter studies, and they allow researchers to consider regional environmental change. Lower trophic level dynamics, regardless of time-scale (i.e. days to weeks to years), are complex, and require studies at multiple spatial and temporal scales to understand. In this talk, the author examines an unusual long-term data set on phytoplankton, zooplankton, and nutrient dynamics and attempts to explain variation in terms of a variety of local and regional environmental variables. In many ways, this is a daunting task, but valuable practical lessons emerge. For example, (and this is rhetorical) How can CALFED evaluate large-scale regional changes (e.g. change in precipitation regime) that may influence (or even CONFOUND) monitoring programs on localized, restoration actions? CALFED's evaluation of restoration actions will be highly dependent on scientific INFERENCE that stems from large-scale field-level analyses (e.g. # of smolt of species X found in shallow water habitat Y). Such

INFERENCE can be confounded on a variety of levels, but long-term data sets provide increased confidence AND help partition local and regional influence.